

Annual variations of quantitative EEG in patients with chronic epilepsy

Sobaniec W*, Kulak W, Bielewicz B, Sobaniec P

Department of Pediatric Neurology and Rehabilitation, Medical University of Białystok, Poland

* CORRESPONDING AUTHOR:

Department of Pediatric Neurology and Rehabilitation,
Medical University of Białystok,
17 Waszyngtona str.
15-274 Białystok, Poland
telephone: +48 85 7450812; fax: +48 85 7450812
e-mail: kneur2@wp.pl (Wojciech Sobaniec)

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ABSTRACT

Purpose: Annual changes in powers of the close-eyed EEG were measured over 12 months in 12 patients with epilepsy.

Material and Methods: The present study included 12 patients aged 14.6 ± 2.7 years with chronic epilepsy, suffering for 6-14 years. EEGs were recorded every month between 9 and 11 a.m. Five patients had generalized seizures and 7 partial complex seizures secondarily generalized. Visual analysis of EEG was performed before the quantitative assessment. The signals were recorded using a set of 14 (F3, F4, F7, F8, C3, C4, P3, P4, O1, O2, T3, T4, T5, T6) scalp electrodes. For each patient, 20 artifact-free EEG epochs, each of 2 s. duration were selected for spectral analysis to calculate spectral power. The sampling frequency was 240 Hz. Frequencies below 1 Hz and above 70 Hz were eliminated by digital filtering. The channels were recorded relative to a vertex reference. A fast Fourier transformation algorithm of signal processing was used to obtain the power spectrum of each lead. Absolute power spectrum was calculated within 4 frequency bands: delta (1-3.99 Hz), theta (4-7.99 Hz), alpha (8-12.99 Hz), and beta (13-30.99 Hz).

Results: We found the abnormalities to be predominantly focal in EEG. None of the EEG recordings were normal, and the power spectra differed over the year. A statistically significant increase of delta and theta bands in May and a decrease of alpha bands in September was found. We did not find positive correlations between the changes in the quantitative EEG analysis and the number of seizures in patients.

Conclusions: These findings suggest the annual variations of EEG in patients with chronic epilepsy. Furthermore studies are needed to clarify the annual variations of EEG among healthy volunteers.

Key words: annual variations EEG, epilepsy, quantitative EEG, power spectra

INTRODUCTION

Human electrocortical activity has been shown to exhibit important diurnal [1,2] and circadian variations [3]. Even if inter-individual differences exist [3,4], significant variations have been described at least for the classical EEG bands in groups of healthy subjects. Theta band power is at its maximum value at 4 p.m. during the diurnal period [2] and at midnight in a 24 h study [3]. Maximum value of alpha power occurs during the afternoon whatever diurnal or 24 h period is studied [5]. The cerebral rhythms renderable by the EEG show fluctuations with several characteristic periodicities [6]. The band power in the 15-30 Hz (beta) with a medium frequency of 14% occurred in May with the frequency of alpha band power in

EEGs fluctuated in inverse proportion and was at its peak during summer. Conspicuous among pathological EEG characteristics were grouped dysrhythmias that occurred about twice as often in summer as in winter.

Seasonal and circadian rhythms of seizures were demonstrated in rodents [7,8]. In the night and morning time, seizure resistance in mice increased [9]. Circadian rhythms of epileptic convulsions were also described in humans [7,8,10]. The sleep-wake cycle is important in modulation of seizure occurrence. Most seizures in experimental and human partial epilepsies tend to recur during the light portion of the light-dark cycle [11].

Apart from conventional EEG, spectral EEG analysis can provide useful information about the epileptic focus [6]. EEG

background activity from 99 epileptic patients and 146 healthy subjects was examined by a conventional spectral EEG analysis method. In patients, quantitative EEG analysis was most successful in the lateralization of epileptic abnormalities and was also helpful in discrimination of epileptic patients from normals in the case where visual EEG interpretation was normal. Clemens [8] investigated spectral power, inter- and intra-hemispheric coherence in the interictal scalp EEG in 41 patients with idiopathic generalised epilepsy. Delta and theta percent power was greater in generalized epilepsy than in controls.

To our knowledge, no quantitative EEG analysis study over a year has been conducted in patients with epilepsy.

The aim of this study was the quantitative EEG analysis over 12 months in 12 patients with chronic epilepsy.

MATERIALS AND METHODS

The present study included 12 patients aged 14.6 ± 2.7 years with chronic epilepsy, suffering for 6-14 years. They are free of psychiatric disease. The patients have been maintained on a stable dose of their standard antiepileptic drug therapy for at least 30 days. EEG were performed between 9 and 11 a.m. every month (28 ± 3 days). In case of epileptic attacks, the EEG recordings were made after 3 days of seizures. We used a 3-day interval between epileptic seizures and EEG recording to normalize the background EEG activity. Five patients had generalized seizures and 7 partial complex seizures secondarily generalized. The mean duration of epilepsy was 7.7 ± 2.5 years. The average number of seizures was 2.2 per 2 months. Nine patients had valproate therapy, three had carbamazepine and three patients had oxcarbazepine therapy. Seven children had monotherapy and five polytherapy.

EEG recordings were performed while the patients were in a resting state with eyes closed, lying in a sound-attenuated room. EEG signals were recorded from scalp electrodes (according to the International 10-20 system), all correlated with the vertex reference. The signals were recorded using a set of 14 (F3, F4, F7, F8, C3, C4, P3, P4, O1, O2, T3, T4, T5, T6) scalp electrodes, and amplified and filtered by a Medelec DG Compact 32. We used Ag/AgCl electrodes, with an impedance less than $5k\Omega$. Visual analysis of EEG was performed before the quantitative assessment. For each patient, 20 artifact-free EEG epochs, each of 2 s. duration were selected for spectral analysis to calculate spectral power. The sampling frequency was 240 Hz. Frequencies below 1 Hz and above 70 Hz were eliminated by digital filtering. The channels were recorded relative to a vertex reference. A fast Fourier transformation algorithm of signal processing was used to obtain the power spectrum of each lead [12]. For the statistical evaluation of the EEG phenomena: absolute power spectrum was calculated within 5 frequency bands: delta (1-3.99 Hz), theta (4-7.99 Hz), alpha (8-12.99 Hz), and beta (13-30.99 Hz).

Statistical Analysis

The percentage reduction of EEG power spectra seizures during 12 months determined using the chi-square test. Statistical calculations were performed using Statistica 5.0 PL. For all the analyses, we took the two-tailed significance ($p < 0.05$). The investigational protocol was approved by the Local Ethics Committee of the Medical University of Bialystok.

RESULTS

Twelve patients entered the study, and completed the whole 12-month trial. We found the abnormalities to be predominantly focal. The bitemporal ictal changes in EEG were recorded in five patients. General EEG seizures were noted among four children. The left temporal focal changes were found in two patients, and right focal changes was detected in one child. None of the EEG recordings were normal. The power spectra in 14 electrodes F3, F4, F7, F8, C3, C4, P3, P4, O1, O2, T3, T4, T5, T6 were analyzed for 12 months. The power spectra differed over the year. The results of power spectra analysis are presented in *Fig. 1-4*.

A significant ($p < 0.001$) decrease in the alpha rhythm was found in May and September (*Fig. 1*). Conversely, a significant ($p < 0.001$) increase in the theta bands was noted in May and September (*Fig. 2*). Similarly, a more pronounced ($p < 0.001$) delta rhythm was found in May (*Fig. 3*). On the other hand, the EEG beta bands increased in May, but not significantly ($p > 0.05$) (*Fig. 4*). Furthermore, we did not find positive correlations between the changes in quantitative analysis (increase of the delta and theta rhythm or decrease of alpha rhythm) and the number of seizures.

DISCUSSION

In the present study, we found a significant increase of delta and theta bands in May and a decrease of alpha bands in September. In our opinion, the significant EEG changes in September were correlated with the beginning of the school year. School-related stress could be responsible for these effects.

We did not find positive correlations between the changes in quantitative analysis (increase of the delta and theta rhythm or decrease of alpha rhythm) and the number of seizures. These findings suggest the annual variations of EEG in patients with chronic epilepsy. In our previous report (unpublished data), we found seasonal variation of the first epileptic seizures in 400 children during years 1991-2000. More often, the first seizures occurred in January, April and September. These findings are partially in accordance with the present study. On the other hand, we should mention that the patients in the current report have had chronic epilepsy and have received antiepileptic drugs for several years.

Figure 1. Spectral power of alpha band of epileptic patients (n=12) for 12 months. Data are expressed as mean value \pm SD.

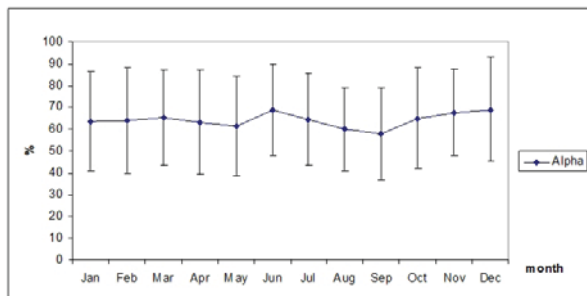


Figure 2. Spectral power of theta band of epileptic patients (n=12) for 12 months. Data are expressed as mean value \pm SD.

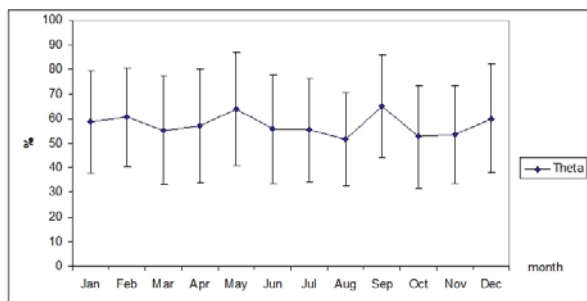


Figure 3. Spectral power of theta band of epileptic patients (n=12) for 12 months. Data are expressed as mean value \pm SD.

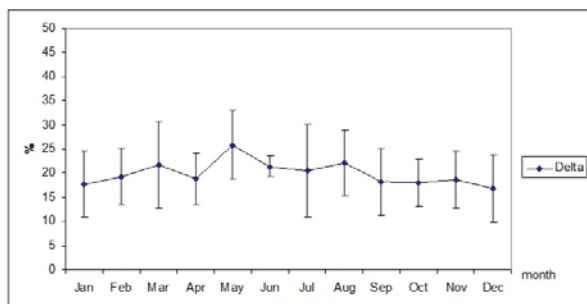
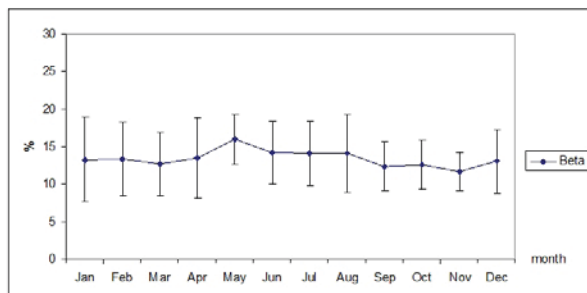


Figure 4. Spectral power of theta band of epileptic patients (n=12) for 12 months. Data are expressed as mean \pm SD.



Our results are also similar to other earlier reports on the seasonal fluctuations of the EEGs [4,5,6]. The cerebral rhythms rendable by the EEG show fluctuations with several characteristic periodicities. The ultradian region with a range from several seconds to twenty hours is divided into three sections. The pathological and physiological EEG-

characteristics are influenced by the physiological rhythms of 2-100 seconds. The periods of 60-140 minutes with a medium cycle of approximately 90 minutes are typical for sleep, the phases of which are shown by the EEG and recording of rapid eye movements. The periodicity corresponding to the basic rest activity cycle can also be shown on the EEG in a state of wakefulness. Diurnal studies between sunrise and sunset showed frequency variations of some pathological EEG characteristics. The frequency of abnormal rhythms increased evenly from 8 a.m. (3.8%) to 3 p.m. (to 9.5%) [6,10]. The circadian studies with a periodicity of 24 ± 4 hours showed that the diurnal maxima of all frequency ranges occurred almost simultaneously, however, they contained temporal shifts due to their specific structure. The major pertinent differences were shown by frontal and temporobasal cerebral areas. Moreover, the circadian studies of sleep phases of primates showed a maximum for delta activity at 1 a.m. and for theta activity at 5 a.m.

The results of the present study are partially in the agreement of Machleidt's and Gtjahr's study [6]. They studied the EEGs in healthy people. The authors detected that beta-EEGs with a medium frequency of 14% occurred in May, with the frequency of alpha-EEGs fluctuating in inverse proportion and reaching its peak during summer.

The other report, Cummings et al., [5] evaluated the change in power in standard waveband frequencies of quantitative EEG data over a 24 h period, in a drug-free representative healthy volunteer population. They concluded that a diurnal variation exists in the EEG rhythms (alpha and beta). Similar results were described by Cacot et al., [13].

The time of the EEG recording (morning), in our opinion, was an additional factor that could have an effect on the EEGs. All our patients had the EEG recordings between 9 and 11 a.m. This statement is supported by the Higuchi et al. study [14]. They found significant diurnal variations for alpha power. The alpha power was significantly smaller at 08:00 than at 11:00, 14:00, 17:00 and 20:00 h. The increase in alpha power was greater at 14:00 than at 08:00 and 20:00 h.

The quantitative EEG analysis can be a useful tool for the determination of the EEG bands, especially the delta and alpha bands for physiological, pharmacological and clinical research [15-17].

Sannita et al., [18] assessed the background EEG effects (power spectral analysis) and plasma concentration of sodium valproate after acute single-dose administration and during long-term, single-drug treatment, in ten epileptic patients with generalized non-convulsive seizures. A transient decrease of the signal amplitude (preponderant on anterior scalp areas) and of the 12.5 to 45.0 Hz relative power (limited to the posterior electrode derivations) was observed during the first weeks of chronic treatment. These EEG effects were not correlated with the drug plasma concentration levels or with the occurrence of behavioral side effects (e.g. drowsiness), while being concomitant with the reduction of specific epileptic EEG phenomena. In our study, more patients had received

monotherapy with valproate which can be an additional factor of the EEG background activity.

Antiepileptic drug (AED) therapy with either phenytoin or carbamazepine has been associated with a generalized slowing of EEG background rhythms [13,14]. In our report, three patients received carbamazepine monotherapy and three had oxcarbazepine therapy.

In the Salinsky et al. [19] study, the AED therapy was associated with an increase in delta and theta power and a slowing of the dominant posterior rhythm.

Several hypotheses (solar system, moon effect, winds, air pressure, rains, temperature) on the EEG fluctuations have been presented in scientific literature [20-23]. One of them, states that there is an effect of the Earth's magnetic field on EEG [24].

Sastre et al., [24] examined the effects of controlled changes in the Earth's magnetic field on EEG. Fifty volunteers were exposed (double-blind) to changes in field magnitude, angle of inclination, and angle of deviation. Volunteers were also exposed to magnetic field conditions found near the North and South Pole. The authors did not find EEG spectral differences as a function of gender or recording site. Moreover, the magnetic field alterations had no effect on total energy (0.5-42 Hz), energy within traditional EEG analysis bands. They concluded that humans have little ability to detect brief alterations in the geomagnetic field, even if these alteration are of a large magnitude.

CONCLUSIONS

The present study supports the annual variations of the EEG rhythms in patients with chronic epilepsy. Further studies are needed to clarify the annual variations of EEG among healthy volunteers.

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